

What is claimed is:

- 1 1. A method for inspecting a phase shift mask that is used with an optical exposure
2 system under a set of exposure conditions, said method comprising:
3 acquiring a plurality of aerial images of said phase shift mask using a transmitted
4 light, said plurality of aerial images being acquired within a process window of said
5 exposure system and using said set of exposure conditions; said plurality of aerial images
6 including a first and a second aerial image of a phase shift mask; wherein said first aerial
7 image of said phase shift mask is in a first out of focus condition, and said second aerial
8 image of said phase shift mask is in a second out of focus condition; and
9 comparing said first and said second aerial images to detect phase defects and
10 errors in said phase shift mask.
- 1 2. The method of claim 1, wherein said first out of focus condition is a positive out
2 of focus condition, and said second out of focus condition is a negative out of focus
3 condition.
- 1 3. The method of claim 1, wherein prior to said comparison step, said first and
2 second aerial images are transformed to simulate a behavior of an exposure system and
3 photoresist.
- 1 4. The method of claim 1, wherein said acquired aerial images of said phase shift
2 mask are magnified in relation to corresponding images created on photoresist by said
3 optical exposure system using said phase shift mask.
- 1 5. The method of claim 1, further comprising automatically processing results of
2 said comparison.
- 1 6. The method of claim 1, further comprising using results of said comparison to
2 produce a map of said variations in said phase of said phase shift mask.
- 1 7. The method of claim 1, wherein said transmitted light is provided using a
2 pulsating light source.
- 1 8. The method of claim 7, wherein said pulsating light source is a pulsating laser.

1 10. The method of claim 7, wherein said acquiring said plurality of aerial images
2 comprises providing continuous relative movement between said laser and said phase
3 shift mask.

1 11. An apparatus for inspecting a phase shift mask that is used with an optical
2 exposure system under a set of exposure conditions, said apparatus comprising:

3 a scanner for acquiring a plurality of aerial images of said phase shift mask under
4 said set of exposure conditions; said plurality of aerial images of said phase shift mask
5 comprising a first and a second aerial image of said phase shift mask; wherein said first
6 aerial image of said phase shift mask is in a first out of focus condition, and said second
7 aerial image of said phase shift mask is in a second out of focus condition; and

an image processing module for detecting variations in phase of said phase shift mask using said first and said second aerial images of said phase shift mask.

1 12. The apparatus according to claim 11, wherein said first out of focus condition is a
2 positive out of focus condition, and said second out of focus condition is a negative out of
3 focus condition.

1 13. The apparatus according to claim 11, wherein said scanner comprises a plurality
2 of cameras for acquiring said plurality of aerial images of said phase shift mask.

1 14. The apparatus according to claim 13, wherein said plurality of cameras comprises:
2 a first camera for acquiring said first image of said phase shift mask; and
3 a second camera for acquiring said second image of said phase shift mask.

1 15. The apparatus according to claim 14, wherein:
2 said first camera is out of focus in a positive direction; and
3 said second camera is out of focus in a negative direction.

1 16. The apparatus according to claim 13, wherein:

2 said scanner further comprises a light source for illuminating said phase shift
3 mask with an illuminating light; and
4 said plurality of cameras are sensitive to said illuminating light.

1 17. The apparatus according to claim 16, wherein said light source is a pulsating light
2 source.

1 18. The apparatus according to claim 17, wherein said pulsating light source is a
2 pulsating laser.

1 19. The apparatus according to claim 11, further comprising a means for effecting
2 continuous relative movement between said scanner and said phase shift mask.

1 20. The apparatus according to claim 17, further comprising a means for effecting
2 continuous relative movement between said laser and said phase shift mask.

1 21. The apparatus according to claim 14, wherein said scanner further comprises:
2 a transmission light illumination system for illuminating said phase shift mask;
3 an optical system for collecting light emerging from said phase shift mask and
4 creating aerial images of said phase shift mask in said first and said second cameras.

1 22. The apparatus according to claim 21, wherein said optical system of said scanner
2 further comprises a numerical aperture diaphragm for reproducing said set of exposure
3 conditions.

1 23. An apparatus for inspecting a phase shift mask that is used with an optical
2 exposure system under a set of exposure conditions, said apparatus comprising:
3 a light source;
4 transmission light illumination means for illuminating said phase shift mask;
5 optical means for producing a plurality of magnified aerial images of said phase
6 shift mask under said set of exposure conditions, said optical means having a numerical
7 aperture diaphragm for reproducing said set of exposure conditions;
8 imaging means for acquiring said plurality of magnified aerial images of said
9 phase shift mask; said plurality of aerial images of said phase shift mask comprising a

10 first and a second aerial image of said phase shift mask; wherein said first aerial image of
11 said phase shift mask is in a first out of focus condition, and said second aerial image of
12 said phase shift mask is in a second out of focus condition; and
13 image processing means for analyzing a condition of said phase shift mask using
14 said plurality of aerial images of said phase shift mask.

1 24. The apparatus according to claim 23, wherein said first out of focus condition is a
2 positive out of focus condition, and said second out of focus condition is a negative out of
3 focus condition.

1 25. The apparatus according to claim 23, wherein said light source is a pulsating light
2 source.

1 26. The apparatus according to claim 25, wherein said pulsating light source is a
2 pulsating laser.

1 27. The apparatus according to claim 23, further comprising a means for effecting
2 continuous relative movement between said scanner and said phase shift mask.

1 28. The apparatus according to claim 26, further comprising a means for effecting
2 continuous relative movement between said laser and said phase shift mask.

1 29. The apparatus according to claim 23, wherein said imaging means further
2 comprises a plurality of cameras for acquiring said plurality of magnified aerial images of
3 said phase shift mask when the phase shift mask is illuminated by said transmission light
4 illumination means.

1 30. The apparatus according to claim 29, wherein said plurality of cameras comprises:
2 a first camera for acquiring said first image of said phase shift mask;
3 a second camera for acquiring said second image of said phase shift mask; and
4 said first and said second aerial images of said phase shift mask being
5 respectively acquired by said first and said second cameras when the phase shift mask is
6 illuminated by said transmission light illumination means.

1 31. The apparatus according to claim 30, wherein:

2 said first camera is out of focus in a positive direction; and
3 said second camera is out of focus in a negative direction.

1 32. The apparatus according to claim 23, further comprising a post process and
2 review means for displaying said condition of said phase shift mask in a graphical form.

1 33. The apparatus according to claim 30, wherein:
2 a wavelength of the light source is identical to the wavelength of the exposure
3 system; and
4 said first and said second cameras are sensitive to said spectrum of said laser light
5 source.

1 34. The apparatus according to claim 23 further comprising a homogenizer disposed
2 in the vicinity of said transmission light illumination means for reducing speckle resulting
3 from use of said light source.